6. BRAKE SYSTEMS

With the advent of composition brake shoes, brake shoe sparks and fragments are much less common as the cause of right-of-way (R/W) fires, unless the shoe is worn out. Much less common, but not unheard of, are explosive arcing of dynamic brake grids and shavings of hot metal from wheels and rails. In the past, it has often been assumed that brake shoe caused fires were confined to down grades and areas where trains were stopping. This is not necessarily so. Various types of malfunctions can cause hot brake shoe chips to fly off on upgrades or level high-speed tracks.

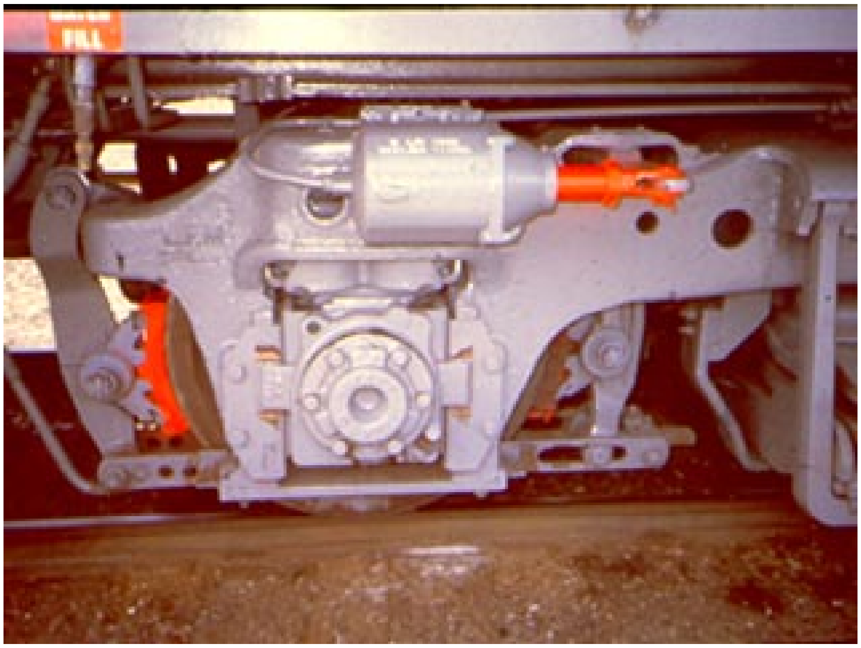
Photograph 6-1.
Switch Engine, Cast Brake Shoes with Wear Indicators

Photograph 6-2.
Composition Shoes

Photograph 6-3.
Switch Engine, Flanged Cast Shoes (has more braking power)

Photograph 6-4.
Cast Brake Shoes (Note Wear Indicators - Center of Shoe)

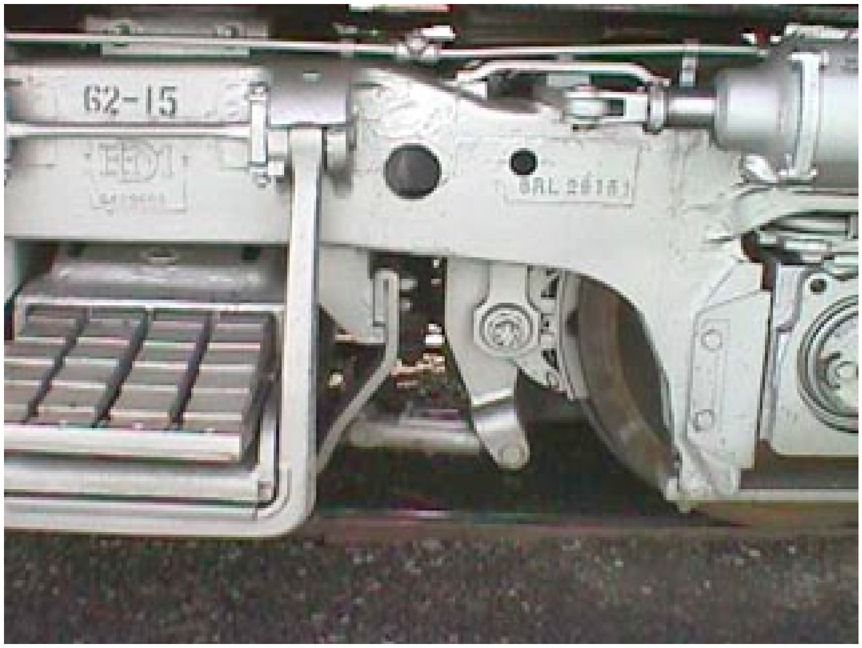
Photograph 6-5.
Worn Brake Shoes (Left: Composition Shoe; Right: Cast Iron)



Photograph 6-6.
Brake System

6.1 Air Brakes

Train air brakes are a combination of mechanical devices operated by compressed air, arranged in a system and controlled manually or pneumatically, by means of which the motion of cars and locomotives is retarded or stopped. The air is supplied by a compressor mounted on the locomotive. It is delivered to the cars through a brake pipe in each locomotive and car, and to the flexible hoses and couplings between them. A series of valves, air reservoirs and pistons transforms changes of pressure in the brake pipe into application or release of pressure by the brake shoes against the wheels.



Photograph 6-7.
Composition Brakes

These changes in brake pipe pressure are normally initiated deliberately by the locomotive engineer but may be initiated from other positions or by malfunctions. A fundamental understanding of train brake systems and how they operate is necessary if we are to be effective in preventing fires from this cause. All railroad rolling stock is equipped with air brakes. Most modern road locomotives are also equipped with dynamic brakes. These two braking systems are often used together. One affects the other in various ways. Therefore, this chapter is divided into three sections, one for each system alone and one for combination use.

Through the automatic brake valve located on the control stand, the locomotive engineer supplies air to the brake pipe in the locomotive and cars. This air charges the auxiliary and emergency air reservoirs of the car brake equipment and the auxiliary reservoirs on the locomotive. Various settings of the automatic brake valve handle then vary the brake pipe pressure to cause the automatic train brakes to apply or release at service or emergency rates. A separate handle on the brake valve allows the engineer to control the air brakes on the locomotive independently of those on the rest of the train if desired. The initial brake pipe pressure depends on company policy and operating conditions. The most common pressure is 90 psi.

By reducing this pressure the engineer causes air to move on each car from the auxiliary or emergency reservoir, or both, to the brake cylinder, forcing the piston out and through a system of rods and levers, causing the brake shoes to rub against the wheels.

Restoring brake pipe pressure to normal reverses the process and releases the brakes.

Locomotive air brakes seldom cause right-of-way fires for two reasons. First, there is less opportunity for a malfunction between the brake valve and the brake shoe. Secondly, all modern road engines are equipped with brake shoes of composition rather than cast iron. So long as they are replaced before wearing too thin, composition shoes will not shed chips or flakes of hot metal. Passenger cars and new freight cars (those built since 1970) also use composition brake shoes.

Malfunctions can happen at many different places and from various causes, most of which would be invisible or unrecognizable to a fire agency inspector. On the other hand, the results or symptoms are usually visible and should be recognized by the inspector. He/she should also know what must be done to correct the problem or to isolate the offending car from the train brake system. He/she should never attempt to take such action personally, but should merely satisfy him/herself that company employees have corrected the situation.

The most obvious result of an air brake malfunction is smoke being given off by brake shoes dragging against wheels. Another indicator is an extended brake cylinder piston when those on all other cars are retracted (train brakes released) or a retracted piston when the others are extended (brakes set). On some new cars the brake cylinders are mounted on the wheel trucks and are not readily visible from alongside the car.

In any of the above situations, the offending car should be isolated from the train brake system and its own brakes released until the cause of the malfunction can be determined and corrected. So long as only one car (or a very few in a long train) is isolated, the safety of the train for shortage of braking power is not affected. Trains must have 85% effective brakes and no more than three consecutive cars with inoperative brakes. Isolation is accomplished by closing the cutout cock between the brake pipe and the control valve. Brake release is done by pulling or pushing on the release rod which releases the air in the brake cylinder. This can only be done by a railroad employee, never by a fire agency inspector. The brake shoes may not separate from the wheels until the train starts to move but there will be no pressure on them and the piston will retract.

Retaining valves (retainers) control the exhaust of brake cylinder air. In their normal operating position the air is exhausted directly and quickly when the engineer returns brake pipe pressure to normal. Their purpose is to retain a steady pressure or a controlled slow release depending on which position the handle is set. These valves were originally developed as a safety measure, which would allow the engineer to recharge the air system without losing all braking action on the train. This was quite necessary to avoid runaways by heavy trains on long downgrades. Modern dynamic brakes have largely taken over the function of retainers, which are seldom used in normal operation now. Retainers are still required to be installed on all railroad rolling stock as a back-up safety system. Since retainers create prolonged brake shoe pressure on the wheels, they cause overheating and sparking. Agency inspectors should, therefore, report any they observe in other than normal position.

Photograph 6-8.
ABD, Retainer and Brake Cylinder

Photograph 6-9.
Retainer Valve

The various items referred to above - brake cylinder and piston, cut-out cock, control valve, release rod, retainers - are located in different places on different types of cars. This is particularly true of specialty cars, e.g., automobile cars, hopper cars, tank cars, etc. Anyone who is expected to inspect railroad rolling stock should make it a point to learn the configuration of as many types of cars as possible.

FRA rules require testing of train air brake systems at various times and places. Most operating companies conduct additional and/or more detailed tests. These air brake tests are done to ensure train safety rather than for fire prevention purposes. They do, however, affect fire prevention because they assure that, at least at the time and place where the test is made, the brakes are operating properly, i.e., there are no dragging or excessively worn brake shoes that could throw fire-causing sparks.

A complete test is made at each initial terminal where a train is made up. The test includes setting and releasing air, checking brake pipe leakage and visual inspection of brake equipment on each car. A similar inspection must be made at intervals of not more than 500 miles, where interchange from one company's tracks to those of another company takes place and where cars are added to or deleted from the train. All these tests must be recorded on FRA Form F-6180-48, a copy of which is to be kept in the cab of the control locomotive until the train arrives at its final terminal (49CFR232.10-232.19).

Most Amtrak cars (those built since about 1970) do not use brake shoes. They are equipped, instead, with disc brakes. Fortunately they are all composition brake shoes and rarely spark unless worn.

Inspection Procedures

Airbrake inspections are of three types. The first is the FRA required safety inspection done by company employees. The other two are the roll-by and isolation verification. The roll-by may be done by either company or agency personnel. A fire agency inspector will conduct the isolation verification, usually after a fire has occurred and the train has been stopped.

A roll-by brake inspection is made while the train is moving, preferably at a slow or moderate speed. It is a visual inspection to determine whether or not there are dragging brake shoes, extended brake cylinder pistons, loose or hanging rigging, etc. One person cannot effectively accomplish this kind of inspection. The brake cylinders will never all be on the same side of the train. It is usually difficult to see the shoes on the far side well enough. Therefore, one or more inspectors should be on each side of the train.

Inspectors should not stand too close to the train for two reasons. The first is safety. Loose or protruding items are much more dangerous close to the train. The second is efficiency. It is much easier to observe a moving object if it is not too close. A safe practical distance from the near rail for a roll-by brake inspection must be maintained. **REMEMBER, ALL RAILS MUST BE TREATED AS LIVE - PAY ATTENTION TO YOUR SURROUNDINGS.**

Photograph 6-10.
Incoming Train

During a roll-by or other inspections of rolling stock, inspectors should be alert for conditions which, though not immediate fire risks, are indicators that fire or other problems are imminent. Such things as cracked or chipped wheels, flat wheels (usually heard as thumping sounds), built-up wheel shavings, dragging equipment, etc., should be noted on the LE-38 and reported to the company as soon as possible.

An inspection to verify that a car(s) with defective air brakes has been isolated from the brake pipe requires that the inspector know how this is done and what things should look like after it is done. A company employee will do the actual isolation, either in the presence of an inspector or before the inspector arrives. The inspector must ensure that the branch pipe cutout cock handle is closed and the air released from the brake cylinder and the brake shoes are not dragging on the wheels. All this, except the position of the branch pipe cutout cock handle, can be done without getting under the car. The inspector should get no further under the car than is absolutely necessary to observe the cut-out cock and should stay as short a time as possible. If the inspector finds that he/she is on the wrong side of the car, or needs to observe both sides, **the inspector should go around the end of the train or over a car fitted with climbing rods, NEVER BETWEEN CARS.**

6.2 Dynamic Brakes

Dynamic braking is a system which transforms the mechanical energy of turning locomotive wheels into electrical energy in the traction motors operating as generators and then into heat energy in the resister grids where it is finally dissipated to the atmosphere. The effect is similar to that of a motor vehicle decelerating on compression.

Since dynamic brakes only act to retard the rotation of locomotive wheels, not car wheels, they concentrate the braking force at the head of the train and behind helper or RCE-1 units if present. In this respect they are like the independent locomotive air brakes. That is, they tend to take the slack out of the couplings and cause the cars to bunch up behind the locomotive. This is known as “bunch braking.” It is the opposite of “stretch braking” wherein the cars are strung out as far as possible. Both types of braking are normal and are used legitimately in the proper situation but can cause real problems if used at the wrong time and place. Therefore, dynamic brakes cannot be automatically considered to be the answer to all brake shoe fire problems.

When the engineer switches from power to dynamic brake operation at the control stand, he/she first reduces the diesel engine to idle and then actuates a series of electrical contacts that break the circuit between the main generator and the armatures of the traction motors. He/she then closes the circuit between the traction motors and the grids and closes the circuit to the motors of the grid cooling fans. The main generator continues supplying the field coils of the traction motors but this requires very little power. An appreciable time, a minimum of 10 seconds, is required to avoid electrical damage throughout the system.

Dynamic brakes provide some retarding force any time the locomotive is moving (armatures of traction motors rotating) but this force is much less at very low or very high speeds than it is at designed speed. Designed speed varies slightly for various makes and models but generally falls between 20 and 25 mph. As a general rule, dynamics are about one-third as effective at 70 mph as they are at designed speed. Effectiveness of standard dynamics decreases on a straight line from designed speed to zero speed. Most newer locomotives are equipped with “extended range” dynamic brakes which maintain near their maximum effectiveness down to between six and ten mph before dropping off rapidly to zero. In any event dynamics, though useful for slowing a train and reducing the use of air, are not capable of bringing a train to final stop. Air must be used for this.

Various malfunctions may cause dynamic brakes to lose some or all of their effectiveness. Short circuits can happen because of foreign objects or connectors loosened by vibration. One or more of the relays or electrical controls may stick. Any of these occurrences will probably necessitate a switch to air brakes with the attendant risk of brake shoe sparks.

The most serious type of malfunction of dynamic brakes from a fire prevention standpoint is explosive arcing of the grids, which can shower molten metal for 100 feet or more. It will most often be caused by failure or seizure of a blower fan motor. Dynamic brake grids are essentially nothing more than gigantic toaster grids. The difference is that they operate at 600 volts and up to 740 amperes, or 444 kilowatts. The heat generated cannot be dissipated without a large volume of air being blown across the grids continuously while they are operating. In fact, the high-pitched whine of the fan blades is one way to tell that dynamic brakes are in use. If anything stops the fans, overheating and possible arcing of the grids can take place rapidly.

Photograph 6-11.
Cooling Grid (Do Not Walk On)

There is no effective method for making a standing test of dynamic brakes. Ordinarily an engineer will run the controls through the dynamic braking cycle before starting a run to find out if the controls and relays are operating. They make a distinct sound as they open and close, but the engine or train must be in motion before any current will register on the meters.

Inspection Procedures

Dynamic brakes cannot be effectively inspected in the sense that exhaust systems and air brakes can. The locomotive engineer has certain tests that he/she can make in the yard. Basically the fire agency inspector is limited to listening for the whine of the grid cooling fans while the train is in motion. Or he/she may ask questions of the engineer when the train is stopped. On rare occasions the inspector may be called upon to inspect a set of blown out grids. These are easy to identify from the distorted metal projecting through the protective grating. **In any case, agency personnel should remember that dynamic brakes OPERATE AT 600 VOLTS AND ARE DANGEROUS TO GET CLOSE TO.**

6.3 Combination Air and Dynamic Braking

A skillful engineer seldom relies on either air or dynamic brakes alone to control the train. Of course a failure of one system may force him/her to use the other. It is not particularly unusual to rely on air because of failure of dynamics. Failure of the air brake system is more likely to cause either a train separation or a locking up of all the air brakes on the entire train, possibly causing a derailment. In any case, a reliance on dynamic brakes with no air brakes available never happens.

Several situations dictate the use of both systems together in order to properly control the train and also to prevent brake shoe caused fires. Others merely represent good train handling practice.

When the train is moving faster than 25 mph or slower than 20 mph (6-10 mph with extended range dynamics) it is difficult to achieve the desired control with dynamics alone. In the higher speed ranges it may also be dangerous. Therefore, combination braking is usually called for.

Sometimes a train will be too heavy to be controlled with dynamics alone. Depending on locomotive design characteristics, operating speed and grade, a set of dynamic brakes will hold back on a downgrade between 80% and 100% of the load that the same locomotive will pull upgrade. Trainmasters are not supposed to overload trains. They are human however, and mistakes have been made. In this event the engineer will have to supplement dynamics with air.

Except for switching, car pick-up and some short-haul operations, trains are rarely operated with a single locomotive. A group of two or more locomotives is called a “consist.” The dynamic brakes on all locomotives in a consist are operated as a unit. The weight of the train and the grades to be negotiated determine the size of the consist. If one or more of the locomotives in the consist loses its dynamic brakes the remaining units will probably not be enough to control the train without supplementing with air.

Other situations calling for simultaneous use of dynamic and air brakes have to do with “stretch” and “bunch” braking. They may also involve judicious use of the throttle. The purpose is to control the amount of slack in the couplings between the cars. This has important effects on power needs in starting a train to move, negotiating humps or hogbacks and sags or dips as well as in avoiding damage to cargo and rolling stock by jerky operation.